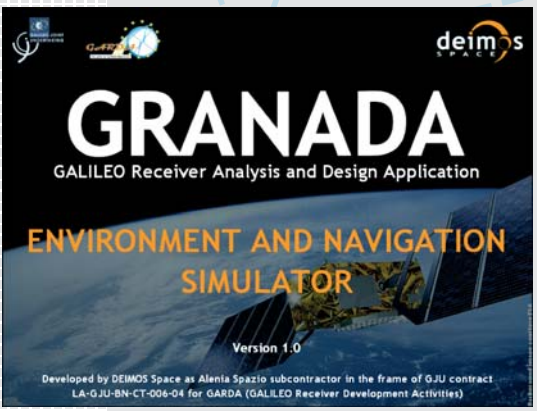
GRANADA

Environment and Navigation



The GRANADA Environment & Navigation simulator is a Galileo/GPS raw data generator and navigation tool. It is oriented to application developers who need external access to raw measurements or PVT solution. It includes realistic characterisation of the effect of the different error components depending on the type of terminal and GNSS receiver configuration. It is possible to configure Galileo and GPS constellations, environmental conditions, satellites and receiver parameters, and navigation algorithm.

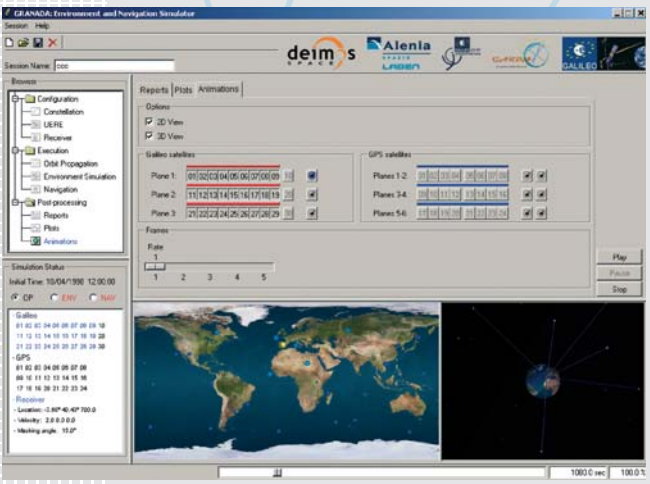
Navigation and environment modelling tool. The GRANADA E&N tool, implemented in C-code, allows the user to simulate the navigation process and analyse the performance of different types of receivers. Pseudorange, carrier phase and Doppler measurements are generated considering satellites and user receiver dynamics, environmental perturbations, receiver configuration, and selected GPS/Galileo carriers and channels. These measures are used to obtain the PVT solution with different navigation algorithms.

Measurement error characterisation. Configurable user equivalent range errors are introduced in the generated measurements. The range errors include satellite and receiver clock modelling, user dynamics, ionospheric and tropospheric delays, receiver tracking errors, multipath, relativistic effects, ephemeris errors and cycle slips. The receiver implements configurable algorithms to correct these perturbations.

Navigation algorithms. The obtained measurements are used to estimate the receiver position, velocity and clock error. Several navigation algorithms can be selected in the user interface, including Least Squares, Recursive Least Squares, and Weighed Least Squares. A carrier-phase smoothing algorithm is also included in the simulator. Both single and dual frequency receivers can be selected to perform PVT computation. It is also possible to compute a combined Galileo-GPS navigation solution (selecting satellites from either constellation with a DOP optimisation criterion).

Graphical user interface and output files. The simulator provides a user interface that allows the configuration of all system parameters, execution of the selected case and the visualisation of simulation outputs results and statistics.

Requirements:
Single PC under Windows: Pentium IV with 256 Mbytes of RAM or higher.



Graphical user interface

- Developed in TLC/TK to provide a COTS-free software
- Used IVRS and XML additional packages for 2D and 3D visualitation and for data-files managing
- Allows different sessions with user configured parameteres and outputs

Requirements

- Single PC under windows: Pentium IV with 256 Mbytes of RAM or higher

General characteristics

- Galileo and GPS constellation, environement and receiver simulator
- Developed in C-code and TCL-TK under Windows (no additional software is required)
- Configurable constellation
- User-defined environment model
- Receiver error modelling and Navigation algorithms
- Graphical user interface to configure the software and visualise the results

Constellation

- Configurable Galileo and GPS constellations
- Configurable satellite clocks
- Constellation visualisation
- DKE perturbations

Errors budget

- Ionospheric and Tropospheric models
- Receiver DLL and PLL tracking errors
- Configurable C/No for different elevation angles
- Multipath model
- Ephemeris errors
- Configurable user equivalent range errors

Receiver

- Configurable Galileo carriers and services
- Default Mass-market, professional, and Safety-Of-Life receiver configurations
- Single and dual frequency receivers
- Configurable receiver position, velocity, data and time
- Configurable masking angle
- Insertion, detection and correction of cycle slips
- Configurable number of channels
- Characterisation of receiver ground clocks
- Navigation algorithms: least squares, weighted least squares, recursive least square and carrier phase smoothing

Outputs

- Graphical and numeric output results, including RINEX format
- Satellites propagation, Navigation results, dilution of precision, visibility, UERE budget results (clock errors, multipath errors, tracking errors, atmospheric errors)

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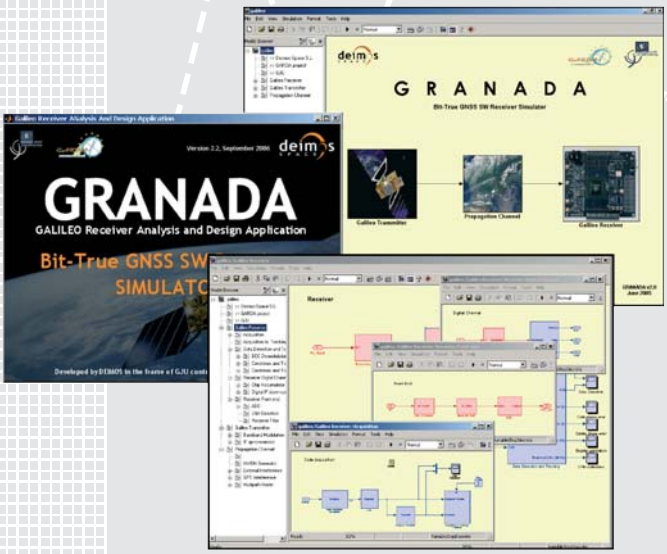
Bit-true GNSS Receiver Simulator



Graphical user interface

GRANADA bit-true simulator includes a user interface that allows the configuration of all system parameters and the visualisation of simulation raw outputs and statistics. The user can obtain C-compiled versions of the Simulink models using autocoding techniques, achieving a 100% performance improvement.

Requirements

Single PC under Windows: Pentium IV with 512 Mbytes of RAM or higher

Matlab/Simulink, with Signal Processing Toolbox and Signal Processing Blockset.

The GRANADA Bit-True Simulator recreates the Galileo and GPS signal-in-space and the receiver signal processing chain using a sampled-based simulation approach. Developed in Matlab/Simulink to provide high modularity, it targets receiver experts in development and analysis of receiver core technologies. The tool enables analyses and simulations of the receiver critical algorithms and architecture design, such as acquisition and tracking, AltBOC performance, multipath and interference analysis. GRANADA can be used as a receiver design test bench that includes the possibility to integrate and analyse user defined algorithms.

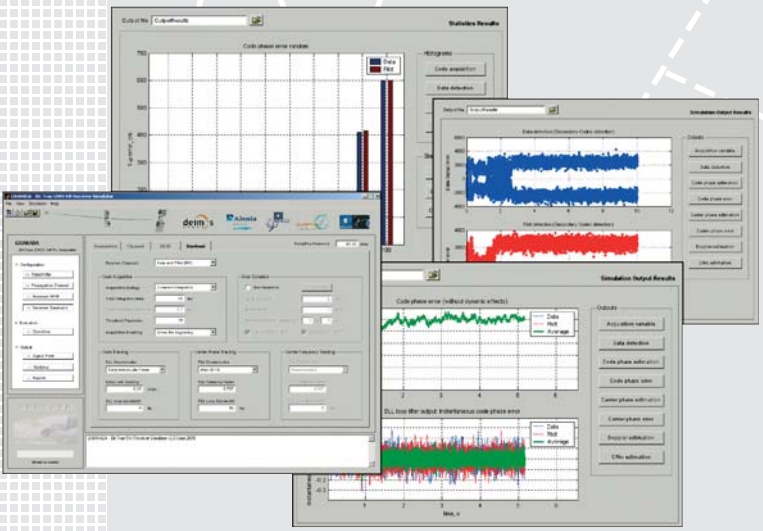
GNSS signal generation. The tool simulates all the Galileo and GPS channels at the selected carrier frequency.It includes ranging codes generation, data and BOC modulation, IF - up conversion and filter design. The transmitter module includes E5 AltBOC modulation scheme, MBOC signals, and the new GPS open service and commercial channels.

Environment model. The propagation channel receiver allows the simulation of different environmental effects, including AWGN, multipath delay, external interference and system dynamics. The multipath model consists of the sum of a direct ray and several indirect paths affected by a random fading component. Interference modelling includes band-limited Gaussian noise and GPS interference. The relative dynamics between the receiver and the satellite is considered including both code and carrier Doppler shifts in the transmitted signal.

Receiver simulation. The receiver is modelled both in floating and fixed-point designs. It includes RF modelling, IF down-conversion, ADC, code acquisition, code and carrier tracking, data detection and C/N_0 estimation. The receiver architecture is capable to simulate any possible sampling frequency or chip spacing.

The simulator modular design allows the modification of the default Simulink model and the insertion of user-defined algorithms, receiver architectures and environment perturbations.

DATA SHEET



Outputs

- Acquisition outputs, data detection, code and carrier phase errors, Doppler shift estimation, C/N0 estimation
- Statistics and Histograms
- Text and mat-files containing the outputs of the simulations

Other features

- Automatic Real-Time Workshop compilation of the Simulink model
- Graphical user interface to control all the simulator capabilities
- Configurable simulation time
- Two simulation modes: IF band-pass signals, and complex low-pass model
- File Management: possibility to run on-the-fly simulations or to load and save intermediate signal from files

Requirements

- Single PC under windows: Pentium IV with 512 Mbytes of RAM or higher
- Matlab/Simulink, with Signal Processing Toolbox and Signal Processing Blockset

General characteristics

- Single-satellite Galileo/GPS signal simulation
- Bit-true simulation at IF of the complete signal processing chain: transmitter, propagation channel and receiver
- Implemented in Matlab/Simulink. Signal Processing toolbox and blockset required
- Highest modularity: user configurable models and algorithms
- Floating-point and fixed-point data types
- GNSS Receiver Toolbox (automatically installed in the user Simulink library)

Transmitter

- IF Signal generation of Galileo E5, E6, L1 and GPS L5, L2, and L1 (with L2C & L1C). Selectable ranging codes.
- BOC/MBOC (including CBOC and TMBOC implementation)
- Configurable IF up-conversion and transmitter filter
- Configurable sampling frequency

Propagation Channel

- User-defined carrier-to-noise density ratio (C/N0)
- Multipath model:
  - Diffuse component and up to 4 reflected rays
  - Configurable delay, relative power, and Doppler bandwidth
  - Rice and Rayleigh power distribution
- GPS interference on Galileo:
  - GPS L1 and L5 interference
  - Configurable Relative Power
  - Possibility of activating the M-code Spot Beam for GPS L1 signal
  - Real GPS ranging codes and modulations
- External interference:
  - Configurable C/I0, interference bandwidth and centre frequency
  - Time interval of the interference

Receiver

- Bi-channel receiver architecture
- AltBOC and BOC demodulation
- Analog-to Digital converter model
- Configurable receiver filter
- IF down-conversion
- Configurable narrow correlator
- Code Acquisition: configurable matched-filter acquisition strategy
- Code Tracking: configurable DLL discriminator, early-late spacing, and loop bandwidth
- Carrier Phase and Frequency Tracking: configurable PLL/FLL discriminators damping factors and loop bandwidth
- User Dynamics: coherent code and carrier Doppler shift
- Carrier-to-noise density ratio estimator
- Floating-point and configurable fixed-point data types

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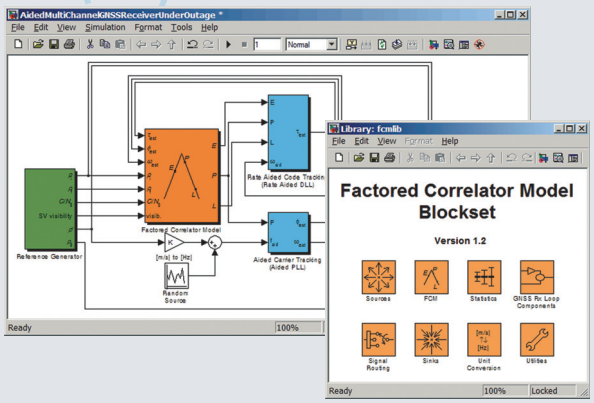
Factored Correlator Model Blockset



The GRANADA Factored Correlator Model (FCM) Blockset is a Simulink library that provides a swift, flexible, and realistic way of simulating different signal processing architectures, either of standalone GNSS receivers or multi-system solutions. It is directed to a wide variety of users – from industry to research – who require simulation speed as well as to access and control internal receiver signals and model system interactions. Based on an analytical model of a GNSS receiver's correlator outputs, it precludes the need for the simulation of low-level signal processing stages, therefore allowing a great increase in simulation speed while still accounting for correlation losses due to different effects. The GRANADA FCM Blockset includes a reference generator, numerous GNSS receiver components, and other utilities to be used with the FCM module, allowing a fast and easy setup of a GNSS receiver's tracking loops.

Graphical User Interface
The Simulink graphical user interface allows an intuitive and functional organisation of the different components, easy access to internal signals, and visualisation tools.

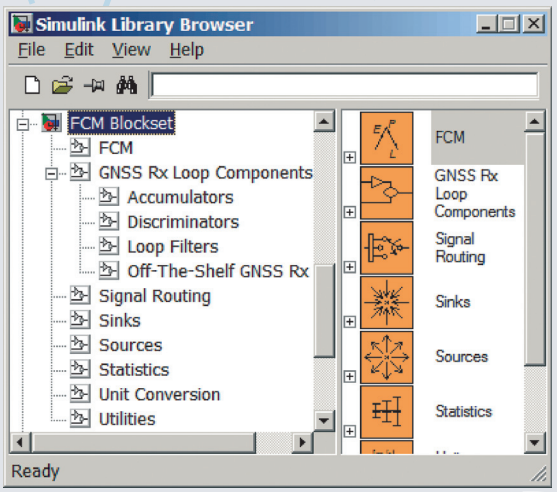
Requirements
Single PC under Windows: Pentium IV with 512 Mbytes of RAM or higher. MATLAB/Simulink, with Signal Processing Toolbox and Signal Processing Blockset.

Fast GNSS receiver simulation. Allowing near real-time simulation of correlator outputs, the GRANADA FCM is the smart choice for the early stages of receiver architecture design and test and for the fast simulation of standalone or hybrid systems where inter-system coupling must be considered.

Realistic modelling. The GRANADA FCM accounts for correlation losses due to carrier phase and frequency errors, code phase error and code Doppler. The model was validated using theoretical and GRANADA Bit-True results, highlighting its reliability and accuracy.

Flexibility. Access to deep receiver signals (I and Q measurements) provides the necessary freedom to design novel algorithms for signal tracking, lock detection, noise level estimation, etc., as well as to develop new receiver architectures for single or multi-system devices. Each effect may be included or not, varying the model's accuracy and allowing the analysis of particular parts of the receiver architecture independently.

Multi-channel. The GRANADA FCM allows the simultaneous simulation of multiple receiver channels with different (and dynamically varying) C/N_0.



Requirements

- Single PC under Windows: Pentium IV with 512 Mbytes of RAM or higher
- MATLAB/Simulink, with Signal Processing Toolbox and Signal Processing Blockset

General characteristics

- Simulink Blockset for GNSS receiver simulation
- Fast, realistic, and flexible modelling of GNSS receiver correlator outputs
- Multi-channel support
- Quick and easy GNSS receiver setup even for inexperienced users

Factored Correlator Model

- Near real-time simulation of multiple channels
- User definable parameters:
  - RF carrier frequency
  - Spreading code period
  - Modulation (supports BPSK(n) and BOC(n,m) modulations)
  - Integration period
  - Correlator spacing
- Accounts for correlation losses due to several effects (which may be turned on/off independently) including:
  - Carrier phase and frequency errors
  - Code delay error
  - Code Doppler influence
  - Noise

Reference Generator

- Reference pseudoranges and pseudorange rates based on satellite ephemeris and a user trajectory file
- C/N0 based on satellite elevation and user defined lookup
- Satellite visibility output

GNSS Receiver Tracking Loop Components

- Coherent and non-coherent carrier and code phase discriminators
- Loop filters with user definable loop equivalent noise bandwidth
- Off-the-shelf aided and unaided code and carrier tracking loops

Outputs

- Correlator Outputs (I and Q measurements)
- Internal tracking loop signals
- Carrier phase and frequency and code delay estimates
- Pseudorange, carrier phase, and pseudorange rate estimates (based on tracking loop outputs)

Other Features

- Power estimation
- Correlator outputs normalization
- Sliding statistics
- Unit conversion

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